IMAGE RETRIEVING APPARATUS

[0001] This application is based on patent applications 2000-339306 and 2000-361566 filed in Japan, the contents of which are hereby incorporated by references.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to an image retrieving technique for judging whether an image in an area of an input image is similar to or the same as a predetermined reference image or not.

2. Description of the Related Art

[0003] Color histogram is conventionally used for judging whether an image in an area of an input image is similar to or the same as a predetermined reference image or not. In the method using the color histogram, a color histogram of the reference image and a color histogram of an image in a predetermined area in the input image are compared. The area in the input image to be compared is moved at a predetermined pitch in the horizontal and vertical directions on the whole input image. The identity or the similarity of the color histogram of each portion of the input image and the color histogram of the reference image are calculated. The area in the input image having the identity or the largest similarity is judged as the area the same as or similar to the reference image. The size of the area in the input image to be compared can be varied corresponding to the size of the

reference image.

[0004] For increasing the processing speed of the image retrieving by the method using the color histogram, it is proposed to vary the pitch of the movement of the area to be compared corresponding to the similarity of the color histograms (see collection of congress of electronic information and communication D-II Vol.J81-D-II No.9 pp.2035-2042 September 1998). In this modification, when the area to be compared is in the vicinity of the area having the lower similarity, the pitch of the movement of the area is varied to be larger. When the area to be compared is in the vicinity of the area having the higher similarity, the pitch of the movement of the area is varied to be smaller. As a result, the processing speed of the image reference can be made faster.

[0005] In the above-mentioned conventional methods, the color histogram is calculated with respect to each image in the area and compared with that of the reference image. Furthermore, the size of the area to be compared can be varied corresponding to the size of the reference image, so that the burden of the image processing becomes larger. Thus, a high performance computer is necessary for processing the image reference. Furthermore, when the color histogram having a fine resolution of gradation is used, the quantity of the calculation necessary for referencing the color histograms becomes much larger.

[0006] Actually, it is desired to know whether a predetermined kind of image such as a person is included in the input image or not, instead of judging whether the same image as the reference image is included in the input image or not. In such the case, the size of the area to be compared is generally known. Thus, it is desired to propose a new method for judging whether a predetermined kind of image is included in the input image or not by a calculation performance such as a one-chip microcomputer used in a household electric appliance.

[0007] On the other hand, in the image retrieving of the input image by using the color histogram, the number of image data of the input image or the reference image is sometimes small, when the density of the image is small or when the size of the image to be compared is small. In such the case, the color histogram will take a comb shape or a discrete histogram including the gradation of zero degree.

[0008] An example that both of the numbers of the image data of the input image and the reference image are small is described with reference to FIGS. 30A to 30E. FIG. 30A shows an input image 201. FIG. 30B shows a reference image 202. Numeral 203 in FIG. 30A designates an area to be retrieved. FIG. 30C shows a normalized color histogram of the area 203. FIG. 30D shows a normalized color histogram of the reference image 202. Hereupon, in the normalized color histogram, a value that the number of the pixels having the same gradation

divided by the number of the total pixels is used as the degree of each gradation, and the sum the degrees of every gradations is normalized to be "1".

[0009] When the numbers of the image data of the input image 201 and the reference image 202 are small, the color histograms of them will be the discrete comb shape including the gradation of zero degree, as shown in FIGS. 30C and 30D. Furthermore, when the luminance in the input image 201 and/or the reference image 202 are/is varied or when the blushing occurs in one or both of the images, the color histogram of the input image 201 will be discrepant from that of the reference image 202, as shown in FIG. 30E, so that the similarity between the input image 201 and the reference image 202 becomes much lower. Thus, an area to be retrieved will erroneously be judged as the area not including the reference image. The similarity is a value calculated that the number of degrees in the color histograms of the input image 201 and the reference image 202 are compared with respect to each gradation, and the smaller degrees are added with respect to every gradations.

[0010] Another example that the number of the image data of the input image 211 is largely different from that of the reference image 212 is described with reference to FIGS. 31A to 31G. FIG. 31A shows an input image 211. FIG. 31B shows a reference image 212. Numeral 213 in FIG. 31A designates an area to be retrieved, and numeral 214 designates another area not

to be retrieved. FIG. 31C shows a normalized color histogram 215 of the area 213. FIG. 31D shows a normalized color histogram 216 of the area 214. FIG. 31E shows a normalized color histogram 217 of the reference image 212.

[0011] In this example, the number of the image data of the area 213 is smaller than that of the area 214, but the number of the image data of the reference image 212 is similar to that of the area 214.

[0012] As can be seen from FIG. 31C, the color histogram 215 which is formed by basing the small number of the image data has a discrete comb shape including the gradation of zero degree. On the other hand, as can be seen from FIGS. 31D and 30E, the color histograms 216 and 217 which are formed by basing the relatively large number of the image data respectively have successive curves taking positive values.

[0013] FIG. 31F shows the color histograms 215 and 217 which are superimposed on the same coordinates. In FIG. 31F, hatched portions 218 correspond to the similarity of the color histogram 215 of the area 213 and the color histogram 217 of the reference image 212. FIG. 31G shows the color histograms 216 and 217 which are superimposed on the same coordinates. In FIG. 31G, a hatched portion 219 corresponds to the similarity of the color histogram 216 of the area 214 and the color histogram 217 of the reference image 212.

[0014] As can be seen from FIGS. 31F and 31G, the color

histogram 215 of the area 213 has the comb shape, so that the similarity of the hatched portions 218 is smaller than that of the hatched portion 219 with respect to the color histogram 217. Thus, the area 214 which is not to be retrieved will erroneously be retrieved as the area including the reference image instead of the area 213 to be retrieved.

[0015] As mentioned above, when the color histogram becomes the comb shape, the similarity of the histogram of an area of the input image with respect to that of the reference image becomes lower even though the gradation is discrepant a little. Especially, when the luminance in the input image is varied, the image retrieving performance will become much lower. Furthermore, when the number of the image data of the input image or the reference image is largely different from the number of the image data of the area to be compared, the image retrieving performance will be reduced.

SUMMERY OF THE INVENTION

[0016] An object of the present invention is to provide an image retrieving apparatus and a method executed therein, by which an area similar to a reference image can quickly be retrieved in an input image without omission.

[0017] Another object of the present invention is to provide an image retrieving apparatus and a method executed therein, by which an area similar to a reference image can precisely be retrieved in an input image when a number of image data is small.

[0018] An image retrieving apparatus in accordance with the present invention retrieves whether an image similar to a predetermined retrieving image to be retrieved is included in an input image or not by comprising the following elements.

[0019] A first area extracting unit extracts a first retrieving area having a first size from the input image with respect to each movement at a first moving pitch. A first histogram forming unit forms a first histogram with respect to each first retrieving area with a first resolution of gradation. A second histogram forming unit forms a second histogram of the retrieving image with the first resolution of gradation. A second area extracting unit compares the first histogram with the second histogram for calculating a similarity of the first histogram with respect to the second histogram, and extracts a retrieving area having the similarity larger than a first level. A third area extracting unit extracts a second retrieving area having a second size from the first retrieving area extracted by the second area extracting unit at a second moving pitch. A third histogram forming unit forms a third histogram with respect to each second retrieving area with a second resolution of gradation which is higher than the first resolution of gradation. A fourth histogram forming unit forms a fourth histogram of the retrieving image with the second resolution of gradation. An area retrieving unit compares the third histogram with the fourth histogram for calculating a similarity of the third histogram with respect to the fourth

histogram, and retrieves an area having the similarity larger than a second level.

[0020] By such a configuration, the image retrieving of the retrieving image in the input image is executed at two stages with different sizes of retrieving areas and different resolutions of gradation of the color histograms. At first, at least one candidate area in which the retrieving image can be included is extracted in the input image by a rough image retrieving with a larger size of the retrieving areas and a rough (lower) resolution of gradation of the color histograms. Subsequently, an area in which the retrieving image is included is extracted in the candidate area by a fine image retrieving with a smaller size of the retrieving areas and a fine (higher) resolution of gradation of the color histograms. Thus, it is possible to lighten the burden for calculating the histograms and to shorten the time for the image retrieving process.

[0021] Another image retrieving apparatus in accordance with the present invention retrieves whether an image similar to a predetermined retrieving image to be retrieved is included in an input image or not by comprising the following elements.

[0022] An area extracting unit extracts a retrieving area having a predetermined size from the input image with respect to each movement at a predetermined moving pitch. A judging unit judges whether a number of pixels included in the retrieving area is smaller than a predetermined value or not. A first

histogram forming unit forms a first histogram with respect to each retrieving area with a first resolution of gradation, and smoothes the first histogram when the number of pixels in the retrieving area is smaller than the predetermined value. A second histogram forming unit forms a smoothed second histogram of the retrieving image. An area retrieving unit calculates a similarity of the first histogram of each retrieving area with respect to the second histogram by comparing the first histogram with the second histogram, and retrieves an area having the similarity larger than a predetermined level.

[0023] By such a configuration, the histograms are smoothed with having no comb shape, so that the similarity of the histogram of the retrieving area in the input image with respect to that of the retrieving image cannot be lower due to the discrepant between the gradations. Thus, it is possible to retrieve the area in the input image similar to the retrieving image precisely.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] FIG. 1 is a block diagram of an image retrieving apparatus in accordance with a first embodiment of the present invention;

[0025] FIG. 2 is a drawing showing an input image and a retrieving area moving in the input image;

[0026] FIG. 3 is a graph for showing an example of a three dimensional color histogram;

[0027] FIGS. 4A and 4B are graphs for showing examples of the color histograms respectively formed with the resolution of gradations N=16 and N=256;

[0028] FIGS. 5A to 5C are graphs for showing a method for calculating a similarity between the color histograms;

[0029] FIG. 6A is a drawing for showing a relation between the input image and the retrieving area moving in the input image in rough image retrieving in the first embodiment;

[0030] FIG. 6B is a drawing for showing the retrieving image 13 to be retrieved in the rough image retrieving in the first embodiment;

[0031] FIGS. 6C to 6E are graphs for showing a method for calculating a similarity between the color histograms in the rough image retrieving in the first embodiment;

[0032] FIG. 7A is a drawing for showing relations between a candidate area to be retrieved and the input image and between the retrieving area and the candidate area moving in the fine image retrieving in the first embodiment;

[0033] FIG. 7B is a drawing for showing the retrieving image to be retrieved in the fine image retrieving in the first embodiment;

[0034] FIGS. 7C to 7E are graphs for showing a method for calculating a similarity between the color histograms in the fine image retrieving in the first embodiment;

[0035] FIG. 8 is a drawing for showing an example of the

candidate area obtained by the rough image retrieving in the first embodiment;

[0036] FIGS. 9A to 9F are drawings respectively for show relations between the input image and the retrieving area or the like in the image retrieving process in the first embodiment;

[0037] FIG. 10 is a flowchart for showing a main routine of the image retrieving steps in the first embodiment;

[0038] FIG. 11 is a flowchart for showing a subroutine of the rough image retrieving in step #110 in the main routine shown in FIG. 10;

[0039] FIG. 12 is a flowchart for showing a subroutine of the fine image retrieving in step #115 in the main routine shown in FIG. 10;

[0040] FIG. 13 is a flowchart for showing a subroutine for deciding an objective area in step #305 in the subroutine shown in FIG. 12;

[0041] FIG. 14 is a drawing for showing an example that the candidate areas are continued and/or overlapped;

[0042] FIG. 15 is a drawing for showing an example that a retrieving image is disposed for bridging two retrieving areas;

[0043] FIG. 16 is a block diagram for showing an example of an electric configuration of a digital still camera using the image retrieving apparatus in accordance with the first embodiment;

[0044] FIG. 17 is an HQ chromaticity diagram for showing an area in which a color of human skin can be reproduced

properly;

[0045] FIGS. 18A to 18C are drawings respectively for showing examples of filters used in edge emphasizing process in a digital still camera using the image retrieving apparatus in accordance with the first embodiment;

[0046] FIG. 19 is a graph for showing examples of gradation characteristics (γ characteristic curves) used in gradation compensation process in the digital still camera in accordance with the first embodiment;

[0047] FIG. 20 is a block diagram for showing an example of an electric configuration of a printer using the image retrieving apparatus in accordance with the first embodiment

[0048] FIG. 21 is a block diagram of an image retrieving apparatus in accordance with a second embodiment of the present invention;

[0049] FIGS. 22A to 22E are drawings respectively for show relations between an input image and a retrieving area or the like in image retrieving process in the second embodiment;

[0050] FIGS. 23A to 23D are graphs for showing smoothing process of a color histogram in the second embodiment;

[0051] FIG. 24 is a flowchart for showing a main routine of image retrieving steps in the second embodiment;

[0052] FIG. 25 is a flowchart for showing a subroutine for forming a normalized color histogram in steps #515 and #525 in the main routine shown in FIG. 24;

[0053] FIG. 26 is a flowchart for showing a main routine of image retrieving steps in a modification of the second embodiment;

[0054] FIG. 27 is a flowchart for showing a subroutine for selecting resolution of gradation "N" in steps #720 in the main routine shown in FIG. 26;

[0055] FIGS. 28A to 28E are graphs for showing smoothing process of a color histogram in another modification of the second embodiment;

[0056] FIG. 29 is a graph for showing examples of gradation characteristics (γ characteristic curves) used in gradation compensation process in the digital still camera in accordance with the second embodiment;

[0057] FIG 30A is the drawing for showing the relation between the input image and the retrieving area moving in the input image in the conventional image retrieving method;

[0058] FIG. 30B is the drawing for showing the retrieving image to be retrieved in the conventional image retrieving method;

[0059] FIGS. 30C to 30E are the graphs for showing the problem in the conventional method for calculating the similarity between the color histograms;

[0060] FIG. 31A is the drawing for showing the relation between the input image and the retrieving image in the conventional image retrieving method;

[0061] FIG. 31B is a drawing for showing the reference image used in the conventional image retrieving method; and

[0062] FIGS. 31C to 31G are graphs of the color histograms for showing the conventional image retrieving method.

DETAILED DESCRIPTION OF THE EMBODIMENT

FIRST EMBODIMENT

[0063] A first embodiment of the present invention is described with reference to the drawings.

[0064] FIG. 1 shows a block diagram of an image retrieving apparatus in accordance with the first embodiment. The image retrieving apparatus 10 comprises an image input unit 1, a color converter 2, a retrieving area setting unit 3, an HQ histogram forming unit 4, an HQ histogram comparator 5, a similarity judging unit 6, an area position memory 7, and a similar area information output unit 8.

[0065] The image retrieving apparatus 10 retrieves whether an input image 11 (see FIG. 2) includes a retrieving image similar to a reference image of an object to be retrieved or not by comparing the similarity of color histograms of the image in an area of the input image and the retrieving image. In this description, a part of the input image similar to the reference image is abbreviated as "retrieving image".

[0066] At first, an area in which the retrieving image can be existed is roughly retrieved. Subsequently, the position of the retrieving image is precisely retrieved in the roughly retrieved

area. In the rough image retrieving of the retrieving image, color histograms having low resolution of gradation are used. In the fine retrieving of the retrieving image, color histograms having high resolution of gradation are used. In both of the rough image retrieving and the fine image retrieving, a size of an area to be compared is selected and the area is moved in predetermined directions at a predetermined pitch so as to scan whole of the input image or the roughly retrieved area. A color histogram is calculated with respect to the image portion at each stop position of the area. All the color histograms are compared with the color histogram of the reference image. In the first embodiment, a human face portion is used as the retrieving image to be retrieved as shown in FIG. 2.

[0067] The image input unit 1 takes an input image 11 and a retrieving image 13 (see FIG. 6B). For example, the input image 11 has 640 (horizontal direction) $\times$ 480 (vertical direction) pixels, and the retrieving image 13 has 60×80 pixels. The input image 11 and the retrieving image 13 are respectively taken as an image data configured by R(red), G(green) and B(blue) color signals.

[0068] The color converter 2 converts the image data configured by R(red), G(green) and B(blue) color signals to another image data configured by hue (H) and compensated saturation (Q) by following equations.

$$H=\cos^{-1}[\{(R-G)+(R-B)\}/2\cdot 1/\sqrt{}\{(R-G)^2+(R-B)\cdot(G-B)\}] \quad \cdots(1)$$

$$Q=[\{(2R-G-B)/2\}^2+\{\sqrt{}(3)(G-B)/2\}^2] \quad \cdots(2)$$

[0069] Since the hue (H) may not be affected by variation of luminance, it is effective for retrieving an object in which the luminance of the object will be predicted. Since the compensated saturation (Q) has a characteristic that the saturation value increases in proportion to the brightness, it is preferable for detecting human skin having relatively high brightness. It can emphasize the human skin much more than the saturation obtained from the Munsell color system.

[0070] The retrieving area setting unit 3 sets the size of the retrieving area 12 which is to be compared with the retrieving image in the rough image retrieving and the fine image retrieving. In the first embodiment, the retrieving area 12 to be compared has a rectangular shape. The function of the retrieving area setting unit 3 in the rough image retrieving is described with reference to FIG. 2.

[0071] As shown in FIG. 2, a length of a horizontal side of the rough retrieving area 12 is set to be ph1, and a length of a vertical side thereof is set to be pv1. When lengths of a horizontal and vertical sides of the input image 11 is shown as PH1 and PV1, the lengths ph1 and pv1 respectively shown by the following formulae.

$ph1 \fallingdotseq PH1/4$ and

$pv1 \fallingdotseq PV1/4$

[0072] By selecting the size of the rough retrieving area 12 is selected to be 1/16 of the size of the input image 11, it is possible to exclude the areas in which the retrieving image is rarely included from candidate areas for the fine image retrieving. When the size of the rough retrieving area 12 is much larger than a preferable size, there is a possibility to exclude the area in which the retrieving image is included. Alternatively, when the size of the rough retrieving area 12 is much smaller than a preferable size, the quantity to be calculated becomes larger. In the first embodiment, the input image 11 has the pixels of 640 × 480, so that the rough retrieving area 12 has the pixels of 160 × 120.

[0073] The pitch of the movement of the rough retrieving area 12 in the horizontal direction is selected to be kh1 and that in the vertical direction is selected to be kv1. The rough retrieving area 12 is moved by the pitch kh1 in the horizontal direction and by the pitch kv1 in the vertical direction so as to scan whole the input image 11. In FIG. 2, the rough retrieving area 12 illustrated by the solid line is moved by the pitch kh1 in the horizontal direction from the position illustrated by the dotted line.

[0074] In the first embodiment, the pitches kh1 and kv1 in the movement of the rough retrieving area 12 is selected as

$kh1 \fallingdotseq ph1/2$ and

$kv1 \fallingdotseq pv1/2$.

[0075] Thus, the pitch kh1 corresponds to 80 pixels and the pitch kv1 corresponds to 60 pixels.

[0076] Subsequently, the function of the retrieving area setting unit 3 in the fine image retrieving is described. When a position of the rough retrieving area to be precisely retrieved is decided by referring the position information of the candidate areas memorized in the area position memory 7. The fine image retrieving is executed so that a fine retrieving area is set in the decided rough retrieving area.

[0077] In the first embodiment, the fine retrieving area 15 (see FIG. 7A) is set to be a rectangular shape, and the coordinates (shi, svi) (i=1, 2, 3 ···) of the pixel at the upper left end of the area is used as the information with respect to the position of the fine retrieving area.

[0078] A size "p" of the fine retrieving area 15 shown in FIG. 7A is set to be that a length of a horizontal side and a length of a vertical side of the fine retrieving area 15 are initially set to be ph2 and pv2. When the fine image retrieving with respect to the rough retrieving area 12 is completed by using the fine retrieving area 15 having a predetermined size "p", the size "p" of the fine retrieving area 15 is reduced by a downsizing ratio "r". The fine image retrieving will be repeated by the same manner until the size "p" of the fine retrieving area 15 becomes equal to or smaller than a predetermined size "P". In the first embodiment,

the initial values of the lengths of the horizontal and vertical sides ph2 and pv2 are selected as

ph2=ph1 and

pv2=pv1.

[0079] The downsizing ratio "r" is selected to be r=0.8. By repeating the image retrieving with the reduction of the size of the fine retrieving area 15, it is possible to prevent the missing of the retrieving with no relation to the size of the retrieving image.

[0080] The predetermined size "P" is selected to be 1/10 of the size of the input image 11. Thus, the pixels of the predetermined size "P" becomes 64×48 pixels. This size is selected to be the minimum size in view of the case that a human face portion is existed as a part of an object in the input image.

[0081] The pitch of the movement of the fine retrieving area 15 in the horizontal direction is selected to be kh2 and that in the vertical direction is selected to be kv2. The fine retrieving area 15 is moved by the pitch kh2 in the horizontal direction and by the pitch kv2 in the vertical direction so as to scan whole the input image 11. Since the values of the pitches have the relations that kv1>kv2 and kh1>kh2, the image retrieving in the fine image retrieving can precisely executed than that in the rough image retrieving. In the first embodiment, the values of the pitches kh2 and kv2 are respectively set to be "1" as the minimum pitch of the movement. By such the selection, it is

possible to execute the image retrieving with no missing.

[0082] The HQ histogram forming unit 4 shown in FIG. 1 generates the normalized color histograms with using the H and Q data of the input image with respect to each retrieving area set by the retrieving area setting unit 3. Furthermore, the HQ histogram forming unit 4 generates the normalized color histograms with using the H and Q data of retrieving image.

[0083] The color histogram shows the number of pixels as the degrees, in which the number of pixels in a predetermined area is two-dimensionally counted with respect to each of the hue (H) and the compensated saturation (Q). The color histogram becomes three-dimensional as shown in FIG. 3 which shows an example of the shape of the color histogram. In FIG. 3, the coordinates corresponding to the hue (H) and the compensates saturation (Q) respectively having the largest number of the pixels in the retrieving area take the largest values. The hue (H) takes a value between 0 to 2π ($0°$ to $360°$), and the compensated saturation (Q) takes a value between 0 to the largest value among the values of R, G and B.

[0084] The normalized color histogram is the color histogram normalized that the sum of the degrees is to be "1" by dividing the number of pixels with respect to each gradation by the total number of the pixels in the retrieving area.

[0085] The HQ histogram forming unit 4 varies the resolution of gradation for forming the color histograms in the

rough image retrieving and the fine image retrieving. When the resolution of gradation in the rough image retrieving is shown by a symbol "Na" and the resolution of gradation in the fine image retrieving is shown by a symbol "Nb", the resolution "Na" is selected to be smaller than the resolution "Nb". In the first embodiment, the resolution "Na" is selected to be 16 and the resolution "Nb" is to be 256.

[0086] The resolution of gradation is the finesse of the gradation. The resolution of gradation "N" means that the number of the division of the gradation is to be "N". When the resolution of gradation is selected to be "N" and the total number of the gradation is to be 256, a width of the gradation becomes 256/N. The color histogram having a large resolution of gradation "N" is called "fine resolution color histogram" and the histogram having a small resolution of gradation "N" is called "rough resolution color histogram".

[0087] In the first embodiment, the resolution of gradation "Nb" in the fine image retrieving is selected to be 256 which corresponds to the highest resolution of gradation of the image retrieving apparatus in accordance with the first embodiment. The resolution of gradation "Na" in the rough image retrieving is selected to be smaller than the highest resolution of gradation of the image retrieving apparatus. In the first embodiment, the resolution of gradation "Na" in the rough image retrieving is selected to be 16 which is proper to show the color distribution

by the histogram. It, however, is possible to select another value such as 32 as the resolution of gradation "Na" in the rough image retrieving.

[0088] FIGS. 4A and 4B show examples of the color histograms which are formed from the same image data having the 256 gradations. FIG. 4A shows the color histogram having the resolution of gradation N=16. FIG. 4B shows the color histogram having the resolution of gradation N=256. For simplifying the explanation, the color histograms are abbreviated to be one-dimensional.

[0089] Since the resolution of gradation "Na" in the rough image retrieving is made smaller, the number of the gradation to be compared for calculating the similarity can be reduced. In the example shown in FIGS. 4A and 4B, the number of the gradation becomes 1/16. Thus, the image retrieving can be made faster owing to the shortening of the calculation time.

[0090] The HQ histogram comparator 5 show in FIG. 1 compares the color histogram of the retrieving area of the input image with the color histogram of the retrieving image. The similarity judging unit 6 calculates the similarity "S" between the compared color histograms and judges whether the similarity "S" is higher than a predetermined level or not. In the rough image retrieving, the similarity "S" is compared with a predetermined first level "S1". In the fine image retrieving, the similarity "S" is compared with a predetermined second level

"S2" which is larger than the first level "S1".

[0091] In the first embodiment, the first level "S1" is selected to be 0.5 (S1=0.5) which is a relatively low value. By such the selection, it is possible to retrieving an area including a human face portion as a candidate portion, even when the size of the human face portion is smaller than the retrieving area and the value of the similarity "S" becomes smaller. Furthermore, the second level "S2" is selected to be 0.8 (S2=0.8). By such the selection, the image retrieving can be executed more precisely in the fine image retrieving.

[0092] A method for calculating the similarity between the color histograms is described with reference to FIGS. 5A to 5C, 6A to 6E and 7A to 7E. FIG. 5A shows a normalized color histogram 21 which is formed from a retrieving area of the input image. FIG. 5B shows another normalized color histogram 22 formed from a retrieving image. FIG. 5C shows that the color histograms 21 and 22 are compared. FIGS. 6A to 6E shows steps for forming the color histogram and for judging the similarity in the rough image retrieving. FIGS. 7A to 7E shows steps for forming the color histogram and for judging the similarity in the fine image retrieving. In these figures, the histograms are abbreviated as one-dimensional.

[0093] For calculating the similarity "S", the degrees of the normalized color histograms 21 and 22 shown in FIGS. 5A and 5B are compared with respect to respective gradations, and the

values of the degrees with respect to respective gradations are summed. Thus, the sum of the degrees in a hatched portion 23 with respect to respective gradation in FIG. 5C corresponds to the similarity "S" ($0 \leqq S \leqq 1$). The larger the similarity "S" becomes, the larger the degrees of the coincidence of both images become.

[0094] FIG. 6A shows a relation between an input image 11 and a retrieving area 12. FIG. 6B shows a retrieving image 13. In the first embodiment, the retrieving image 13 is a human face portion.

[0095] FIGS. 6C and 6D respectively show a normalized color histogram 31 of the retrieving area 12 and a normalized color histogram 32 of the retrieving image 13 which are formed by the HQ histogram forming unit 4. In the rough image retrieving, the resolution of gradation "Na" is selected to be relatively smaller (for example, Na=16).

[0096] The color histograms 31 and 32 shown in FIGS. 6C and 6D are compared by the HQ histogram comparator 5, and a hatched portion 33 shown in FIG. 6E is obtained. A similarity "S" is calculated by the similarity judging unit 6 based on the hatched portion 33. Subsequently, the similarity "S" is compared with the first level "S1" and a candidate area is decided by the result of the comparison.

[0097] FIG. 7A shows relations between the input image 11 and a candidate area 14 which is obtained by the rough image

retrieving, and between the candidate area 14 and a retrieving area 15 (hatched portion). FIG. 7B shows the retrieving image 13.

[0098] FIGS. 7C and 7D respectively show a normalized color histogram 34 of the retrieving area 15 and a normalized color histogram 35 of the retrieving image 13 which are formed by the HQ histogram forming unit 4. In the fine image retrieving, the resolution of gradation "Nb" is selected to be relatively larger (for example, Nb=256).

[0099] The color histograms 34 and 35 shown in FIGS. 7C and 7D are compared by the HQ histogram comparator 5, and a hatched portion 36 shown in FIG. 7E is obtained. A similarity "S" is calculated by the similarity judging unit 6 based on the hatched portion 36. Subsequently, the similarity "S" is compared with the second level "S2" and an area in which the retrieving image 13 is included is decided by the result of the comparison.

[0100] The area position memory 7 in FIG. 1 memorizes positions of the retrieving areas which have the similarities "S" larger than the first level "S1" or the second level "S2". In the rough image retrieving, the retrieving areas having the similarity "S" larger than the first level "S1" are memorized as the candidate areas which will be to be retrieved by the fine image retrieving. In the fine image retrieving, the retrieving area having the largest similarity "S" is memorized as the area in

which the retrieving image 13 includes.

[0101] FIG. 8 shown an example of the candidate area obtained by the rough image retrieving. In this example, "N" number of the candidate areas are existed in the input image 11. A first candidate area A1 is memorized in the area position memory 7 as size information ph1 and pv1, and a position information of a coordinate (h1, v1) at the upper left end thereof. An N-th candidate area AN is memorized in the area position memory 7 as size information ph1 and pv1, and a position information of a coordinate (hN, vN) at the upper left end thereof.

[0102] The similar area information output unit 8 shown in FIG. 1 outputs the area including the retrieving image 13 memorized in the area position memory 7 as a result of the image retrieving.

[0103] Subsequently, steps of the image retrieving in the image retrieving apparatus in accordance with the first embodiment is described with reference to FIGS. 9A to 9F and 10. FIGS. 9A to 9F respectively show relations between the input image 11 and the retrieving area 12 or the like. FIG. 10 is a flowchart showing a main routine of the image retrieving steps.

[0104] In the step #100 in FIG. 10, the input image 11 and the retrieving image 13 to be retrieved are taken as the image data based on the R, G and B signals (see FIGS. 9A and 9B). Subsequently, the image data based on the R, G and B signals are converted to other image data based on the H and Q data (#105).

[0105] In the step #110, the rough image retrieving for obtaining candidate areas 14 in which the similarity "S" between the color histograms of the retrieving area 12 of the input image 11 and the retrieving image 13 is higher than the first level "S1" is executed (see FIGS. 9C and 9D). Details of the rough image retrieving will be described below with reference to FIG. 11 showing a subroutine flow.

[0106] Subsequently, in the step #115, the fine image retrieving for obtaining an area 16 including the retrieving image 13 by basing on the similarity "S" between the color histograms of the retrieving area 15 in the candidate area 14 and the retrieving image 13 is higher than the second level "S2" is executed (see FIGS. 9E and 9F). Details of the fine image retrieving will be described below with reference to FIG. 12 showing a subroutine flow.

[0107] In FIG. 11 showing the subroutine of the rough image retrieving in the step #110, a normalized color histogram of the retrieving image 13 is formed with the resolution of gradation Na=16 (#200). Subsequently, a normalized color histogram of the retrieving area 12 of the input image 11 is formed with the resolution of gradation Na=16 (#205).

[0108] A similarity "Sm" between the normalized color histograms is calculated (#210), and the similarity "Sm" is compared with the first level "S1" (#215). When the similarity "Sm" is larger than the first level "S1" (Sm>S1: YES in the step

#215), the position information with respect to the retrieving area 12 is memorized in the area position memory 7 (#220).

[0109] When the similarity "Sm" is equal to or smaller than the first level "S1" ($Sm \leqq S1$: NO in the step #215) or when the position information is memorized in the step #220, it is judged whether the movement of the retrieving area 12 is scanned whole the input image 11 or not (#225). When the whole of the input image 11 has not been scanned (NO in the step #225), the retrieving area 12 is moved by the predetermined pitch kv1 in the vertical direction or kh1 in the horizontal direction (#230) and returns to the step #205. Alternatively, when the whole of the input image 11 has been scanned (YES in the step #225), the retrieving areas 12 memorized in the area position memory 7 in the step #220 are selected as the candidate areas 14 (#235), and this subroutine will be completed.

[0110] In FIG. 12 showing the subroutine of the fine image retrieving in the step #115, a normalized color histogram of the retrieving image 13 is formed with the resolution of gradation Nb=256 (#300). Subsequently, an area to which the fine image retrieving is decided among the candidate areas 14 (#305). Details of the steps for deciding an objective area to be precisely retrieved will be described with reference to FIG. 13 showing a subroutine flow thereof.

[0111] A normalized color histogram of a retrieving area 15 in the objective area is formed with the resolution of gradation

Nb=256 (#310). Subsequently, a similarity "Sn" between the normalized color histograms is calculated (#315), and the similarity "Sn" is compared with the second level "S2" (#320). When the similarity "Sn" is larger than the second level "S2" (Sn>S2: YES in the step #320), the position information with respect to the retrieving area 15 is memorized in the area position memory 7 (#325).

[0112] When the similarity "Sn" is equal to or smaller than the second level "S2" (Sn≦S2: NO in the step #320) or when the position information is memorized in the step #325, it is judged whether the movement of the retrieving area 15 is scanned whole the objective area or not (#330). When the whole of the objective area has not been scanned (NO in the step #330), the retrieving area 15 is moved by the predetermined pitch kv2 in the vertical direction or kh2 in the horizontal direction (#335) and returns to the step #310.

[0113] When the whole of the objective area has been scanned (YES in the step #330), a size "p" of the retrieving area 15 is compared with a predetermined size "P" (#340). When the size "p" of the retrieving area 15 is larger than the predetermined size "P" (p>P: YES in the step #340), the size "p" of the retrieving area 15 is downsized by the downsizing ratio "r" (#345), and returns to the step #310. Alternatively, when the size "p" of the retrieving area 15 is equal to or smaller than the predetermined size "P" (p≦P: NO in the step #340), the position

information of the retrieving area 15 memorized in the area position memory 7 in the step #325 is outputted as the retrieving result (#350), and this subroutine flow will be completed.

[0114] In FIG. 13 showing the subroutine for deciding the objective area in the step #305, it is judged whether N number of the candidate areas retrieved by the rough image retrieving are continued or overlapped by basing on the coordinates (hi, vi) (i=1 to N) and the sizes (ph1, pv1) with respect to respective candidate areas (#400).

[0115] With respect to the independent candidate areas which are judged not to be continued or overlapped (NO in the step #400), each candidate area is judged as the objective area to be retrieved precisely (#405). In this case, the coordinate (shi, svi) of each objective area corresponds to the coordinate of each independent candidate area.

[0116] On the other hand, with respect to the candidate areas which are judged to be continued or overlapped (YES in the step #400), a rectangular area enclosing the continued or overlapped areas is selected as the objective area to be retrieved precisely (#410). Subsequently, an initial size of the retrieving area in the objective area having a length ph2 of a horizontal side and a length pv2 of a vertical side is selected (#415), and this subroutine flow will be completed.

[0117] FIG. 14 shows an example that the candidate areas are continued and/or overlapped. When the candidate areas are

continued and/or overlapped, the position information of an candidate area is compared with the position information of another candidate area. The smallest vales of the coordinates (hi, vi) of the candidate areas are designated by hi_{min} and vi_{min}, and the largest values of them are designated by hi_{max} and vi_{max}.

[0118] In the above-mentioned case, the coordinate (shi, svi) of the objective area is shown as (shi, svi)=(hi_{min}, vi_{min}). The size of the objective area (a length ph2 of the horizontal side and a length pv2 of the vertical side thereof) is shown as

$$ph2=hi_{max}+ph1-hi_{min}, \text{ and}$$

$$pv2=vi_{max}+pv1-vi_{min}.$$

[0119] It is assumed that the candidate areas 141, 142 and 143 shown in FIG. 14 are continued and/or overlapped. The coordinates of the candidate areas 141, 142 and 143 are respectively shown as (h1, v1), (h2, v2) and (h3, v3). The lengths of the horizontal and vertical sides of them are commonly to be ph1 and pv1. At this time, the minimum values of hi and vi correspond to h1 and v1. The maximum values of hi and vi correspond to h2 and v3. Thus, the coordinate the objective area 140 illustrated by dotted line in the figure becomes (h1, v1). The lengths ph2 and pv2 of the horizontal side and the vertical side of it will be

$$ph2=h2+ph1-h1, \text{ and}$$

$$pv2=v3+pv1-v1.$$

[0120] In the above-mentioned first embodiment, the

candidate areas 14 having a possibility that the retrieving image 13 is included are retrieved at first by executing the rough image retrieving with using color histograms 31 and 32 having low resolution of gradation "Na". Subsequently, the area including the retrieving image 13 is retrieved by executing the fine image retrieving with using the color histograms 34 and 35 having high resolution of gradation "Nb" in the candidate areas 14. Since the resolution of gradation "Na" used in the rough image retrieving is lower, it is possible to reduce the burden of the calculation in the rough image retrieving and to shorten the time necessary for the image retrieving. Furthermore, the fine image retrieving is executed with respect to only the candidate areas 14 obtained in the rough image retrieving. Thus, it is possible to reduce the total burden of the calculation and to shorten the time necessary for retrieving the image.

[0121] The pitches kh2 and kv2 of the movement of the retrieving area 15 in the fine image retrieving are respectively selected to be one pixel, so that it is possible to prevent the missing of the image retrieving. The pitches kh1 and kv1 of the movement of the retrieving area 12 in the rough image retrieving are respectively selected to be larger than the pitches kh2 and kv2 (kh1>kh2, kv1>kv2), so that it is possible to shorten the time necessary for the rough image retrieving.

[0122] In the rough image retrieving, since the first level "S1" serving as a threshold value for judging the similarity "S" is

selected to be relatively small value such as 0.5 (S1=0.5), it is possible to prevent the missing of the image retrieving. In the fine image retrieving, since the second level "S2" is selected to be relatively large value such as 0.8 (S2=0.8>S1), it is possible to execute the fine image retrieving with a high accuracy. Furthermore, since the second level "S2" is selected not to be so large value such as 0.9 or 0.95, it is possible to retrieve not only the same image as the retrieving image 13 but also the image similar to the retrieving image such as a face of another person. Thus, the image retrieving method in accordance with the first embodiment can be applied for processing the most suitable image processing to a human image among the input images.

[0123] Modifications of the first embodiment will be described below. In the first embodiment, the pitches kh1 and kv1 of the movement of the retrieving area 12 in the rough image retrieving are selected to be kh1≒ph1/2 and kv1≒pv1/2. The pitches kh1 and kv1 in the rough image retrieving are not restricted by the above-mentioned example. For example, when the pitches kh1 and kv1 in the rough image retrieving are selected to be kh1≒ph1 and kv1≒pv1 which are substantially the same as the lengths of the sides of the retrieving area 12, there is a possibility that the retrieving image 13 disposed for bridging the retrieving areas 12 as shown in FIG. 15 cannot be retrieved. Thus, it is preferable to select the pitches kh1 and kv1 of the movement of the retrieving image in the rough image

retrieving smaller than half values of the lengths of the horizontal side and the vertical side of the retrieving area 12.

[0124] The coordinate at the upper left end of the retrieving area 12 or 15 is memorized as the position information of the candidate area or the area including the retrieving image. It, however, is possible to memorize the coordinate at the center of the retrieving area 12 or 15 as the position information.

[0125] The first level "S1" and the second level "S2" serving as the threshold values for judging the similarity "S" are respectively selected to be S1=0.5 and S2=0.8. The values of the first level "S1" and the second level "S2" can be varied corresponding to the desired accuracy of the image retrieving.

[0126] In the above-mentioned first embodiment, the hue (H) and the compensated saturation (Q) are used as the color space. It, however, is possible to use the R, G and B signals. Furthermore, it is possible to use another color system such as the HIS (Hue, Intensity, Saturation) color system, the L*a*b* color system, or the L*u*v* color system.

[0127] It is possible further to provide an operating unit 91 illustrated by dotted line in FIG. 1 showing the configuration of the image retrieving apparatus in accordance with the first embodiment. By such a modification, it is possible to input the values of the parameters such as the values of the resolution of gradation "Na" and "Nb", the sizes of the retrieving areas 12 and 15, the values of the pitches kh1, kh2, kv1 and kv2, the values of

the first level "S1" and the second level "S2", and so on by using the operating unit 91.

[0128] In the above-mentioned first embodiment, the retrieving image 13 is taken by the image input unit 1. It, however, is possible further to provide an retrieving data memory 92 illustrated by dotted line in FIG. 1. The data with respect to the retrieving image 13 is previously memorized in the retrieving data memory 92. In this modification, it is possible to memorize the R, G and B signals as the data of the retrieving image 13. Alternatively, it is possible to memorize the H and Q data converted from the R, G and B signals as the data of the retrieving image 13.

[0129] Furthermore, it is possible to memorize the normalized color histogram based on the H and Q data as the data of the retrieving image 13 in the retrieving data memory 92. In this case, it is further possible to memorize the normalized color histograms which are formed with both of the resolution of gradation "Na" and "Nb". Alternatively, it is possible to memorize the normalized color histogram with the resolution of gradation "Nb" only. The normalized color histogram with the resolution of gradation "Na" is calculated from the normalized color histogram with the resolution of gradation "Nb".

[0130] FIG. 16 shows a block diagram for showing an example of an electric configuration of a digital still camera using the image retrieving apparatus in accordance with the first

embodiment.

[0131] An imaging unit 101 of the digital still camera 100 includes an area imaging device such as CCD, in which a plurality of photo-electro converting elements are arranged in two-dimensional, a set of color filters are disposed in front of each photo-electro converting elements. The imaging unit 101 converts optical energy corresponding to an image of an object 109 to electrical color image signals 101R, 101G and 101B corresponding to the color filters and outputs the color image signals 101R, 101G and 101B.

[0132] An optical lens system 102 includes a taking lens, an aperture and a driving mechanism for moving the taking lens and the aperture. The optical lens system 102 focuses the image of the object 109 on the surface of the imaging device of the imaging unit 101.

[0133] An image retrieving apparatus 10 corresponds to that shown in FIG. 1. The imaging retrieving apparatus 10 retrieves whether an input image corresponding to the color image signals 101R, 101G and 101B includes a human face portion (the object 109 includes a human face portion) or not prior to a shutter switch in an operation unit 107 is switched on.

[0134] An imaging operation controller 103 controls the driving mechanism of the optical lens system 102 by following a control program memorized in a memory unit 104. The imaging operation controller 103 executed an automatic focusing control

for focusing the focus of the taking lens of the optical lens system 102 on the human face portion of the object retrieved by the image retrieving apparatus 10.

[0135] Furthermore, the imaging operation controller 103 executes an automatic exposure control for driving the driving mechanism of the optical lens system 102 and the imaging unit 101 so as to take a predetermined aperture value and a predetermined shutter speed (or exposing time) by which the human face portion becomes a proper exposure value.

[0136] In this example, the proper exposure value is EV$\pm$0 with respect to a proper exposure value corresponding to the sensitivity of the imaging device. When the exposure value is designated by eight bit data (0 to 255), a mean value of luminance Y in the retrieving area satisfies $100 \leqq Y \leqq 150$.

[0137] The mean value of luminance Y can be obtained by the following equation, when the values of the color imaging signals 101R, 101G and 101B are respectively designated by symbols "R", "G" and "B".

$$Y=0.299R+0.587G+0.114B$$

[0138] An image processing unit 105 executes predetermined image processing to the color image signals 101R, 101G and 101B by following a control program memorized in the memory unit 104. The image processing unit 105 executes an automatic white balance control for adjusting the ratio of the output of the color image signals 101R and 101B with respect to the color

image signal 101G so that the color data corresponding to the human face portion is included in a proper area 108 as shown in FIG. 17.

[0139] FIG. 17 is an HQ chromaticity diagram for showing an area in which a color of human skin can be reproduced properly. On the HQ chromaticity diagram, a direction toward 0° corresponds red (R), a direction toward +120° corresponds green (G) and a direction toward +240° (-120°) corresponds blue (B). For example, a color data at a point "P" can be designated by hue (H) which is an angle from 0°, and compensated saturation (Q) which is a distance from the center of the chromaticity diagram.

[0140] In the example shown in FIG. 17, the proper area 108 is enclosed by $30° \leqq H \leqq 60°$ and $40 \leqq Q \leqq 150$. Since the digitalized value is shown by eight bit data (0 to 255), so that the compensated saturation Q takes a value between 0 to 255.

[0141] The image processing unit 105 adjusts the ratio of the output of the color image signals 101R and 101B with respect to the color image signal 101G so that the color data corresponding to the human face portion is included in a proper area 108 as shown in FIG. 17, when the color image signals 101R, 101G and 101B are converted to the H and Q data by following the above-mentioned equations (1) and (2).

[0142] It is possible to memorize the proper area 108 in the memory unit 104, previously. Alternatively, it is possible to

input the proper area 108 by using the operation unit 107.

[0143] Furthermore, image processing unit 105 varies a degree for edge emphasizing operation with respect to the retrieving area equal to or smaller than a predetermined level, when the human face portion is retrieved in the input image by the image retrieving apparatus 10. At this time, the degree for edge emphasizing operation is reduced corresponding to the size of the retrieving area including the human face portion or the size of the human face portion.

[0144] Table 1 shows the degree for the edge emphasizing operation and the gradation characteristic (γ) with respect to each region of the size of the human face portion. FIGS. 18A to 18C respectively show examples of filters used in the edge emphasizing operation. FIG. 18A shows the filter having a high degree of edge emphasizing effect. FIG. 18B shows the filter having a middle degree of edge emphasizing effect. FIG. 18C shows the filter having a low degree of edge emphasizing effect.

table 1

RATIO OF HUMAN FACE PORTION	DEGREE OF EDGE EMPHASIZING	GRADATION CHARACTERISTIC
LARGE (30 to 100%)	WEAK	γ =0.4 (a in FIG. 19)
MIDDLE (10 to 30%)	MIDDLE	γ =0.45 (b in FIG. 19)
SMALL (5 to 10%)	MIDDLE	γ =0.5 (c in FIG. 19)
NOT RETRIEVED	STRONG	γ =0.55 (d in FIG. 19)

[0145] As can be seen from table 1, when the ratio of the size of the retrieving area including the human face portion with respect to the size of the input image is in the range from 30 to 100 %, the filter shown in FIG. 18C having the low degree for edge emphasizing effect is used for emphasizing the edge of the retrieving area including the human face portion. When the ratio of the size of the retrieving area including the human face portion with respect to the size of the input image is in the range from 5 to 30 %, the filter shown in FIG. 18B having the middle degree for edge emphasizing effect is used for emphasizing the edge of the retrieving area. On the other hand, when the human face portion is not retrieved in the input image, the filter shown in FIG. 18A having the high degree for edge emphasizing effect is used for emphasizing the edge of the retrieving area.

[0146] Still furthermore, the image processing unit 105 varies the gradation compensation process with respect to whole the input image corresponding to the size of the retrieving area including the human face portion or the size of the human face portion.

[0147] FIG. 19 shows examples of the gradation characteristics (γ characteristic curves) used in the gradation compensation process by the image processing unit 105.

[0148] As can be seen from table 1, when the ratio of the size of the retrieving area including the human face portion with respect to the size of the input image is in the range from 30 to

100 %, the γ characteristic curve "a" (γ =0.4) shown in FIG. 19 is used for compensating the gradation. When the ratio of the size of the retrieving area including the human face portion with respect to the size of the input image is in the range from 10 to 30 %, the γ characteristic curve "b" (γ =0.45) shown in FIG. 19 is used for compensating the gradation. When the ratio of the size of the retrieving area including the human face portion with respect to the size of the input image is in the range from 5 to 10 %, the γ characteristic curve "c" (γ =0.5) shown in FIG. 19 is used for compensating the gradation. On the other hand, when the human face portion is not retrieved in the input image, the γ characteristic curve "d" (γ =0.55) shown in FIG. 19 is used for compensating the gradation.

[0149] A boundary, for example, 30% of the regions of the ratio of the size of the retrieving area with respect to the size of the input image are to be included in one of the adjoining two regions. The boundaries are not restricted by the examples shown in table 1. It is possible to select proper values corresponding to the characteristic of the digital still camera 100.

[0150] The image data of the object 109 after the image processing by the image processing unit 105 is memorized in the memory unit 104 or displayed on a display unit 106. The memory unit 104 is, for example, configured by a ROM, a RAM, an EEPROM or the like. The display unit 106 is configured by, for example, an LCD.

[0151] The above-mentioned modification is described with respect to the digital still camera. The image retrieving apparatus 10 in accordance with the first embodiment can be applied to another imaging apparatus such as a digital video camera for recording a movie.

[0152] FIG. 20 shows a block diagram for showing an example of an electric configuration of a printer using the image retrieving apparatus in accordance with the first embodiment.

[0153] A data receiving unit 111 of the printer 110 receives an image data based on the R, G and B signals transmitted from, for example, a personal computer (PC), and outputs the color image signals 111R, 111G and 111B.

[0154] An image retrieving apparatus 10 corresponds to that shown in FIG. 1. The imaging retrieving apparatus 10 retrieves whether an input image corresponding to the color image signals 101R, 101G and 101B includes a human face portion or not.

[0155] An image processing unit 112 executes image processing operation to the color image signals 111R, 111G and 111B so as to print an image including a human portion properly by following a control program memorized in a memory unit 113. The image processing unit 112 adjusts the ratio of the output of the color image signals 111R, 111G and 101B so that the luminance corresponding to the human face portion becomes proper.

[0156] In this example, the proper value of the luminance is

defined that a mean value of luminance Y in the retrieving area satisfies $100 \leqq Y \leqq 150$, when the luminance value is designated by eight bit data (0 to 255).

[0157] The mean value of luminance Y can be obtained by the following equation, when the values of the color imaging signals 111R, 111G and 111B are respectively designated by symbols "R", "G" and "B".

$$Y=0.299R+0.587G+0.114B$$

[0158] The image processing unit 112 further executes a color balance processing for adjusting the ratio of the output of the color image signals 111R, 111G and 111B so that the color data corresponding to the human face portion is included in a proper area 108 as shown in FIG. 17. By such the color balance processing, the human face portion can be printed with a proper color.

[0159] It is possible to memorize the proper area 108 in the memory unit 113, previously. Alternatively, it is possible to input the proper area 108 by using the operation unit 115.

[0160] Furthermore, image processing unit 112 varies a degree for edge emphasizing operation with respect to the retrieving area corresponding to the size of the retrieving area including the human face portion with respect to the size of the input image, similar to the above-mentioned digital still camera 100. By such the image processing, it is possible to restrict the sharpness of the human face portion so as not to be much higher,

so that the human face portion can be printed properly.

[0161] Still furthermore, the image processing unit 112 varies the gradation compensation process with respect to whole the input image corresponding to the size of the retrieving area including the human face portion or the size of the human face portion as shown in FIG. 19, similar to the above-mentioned digital still camera 100. By such the image processing, it is possible to restrict the gradation of the human face portion so as not to be much higher, so that the human face portion can be printed with proper gradation.

[0162] The image data processed by the image processing unit 112 is used by a printing unit 114 for printing the image on a paper sheet.

SECOND EMBODIMENT

[0163] A second embodiment of the present invention is described with reference to the drawings.

[0164] FIG. 21 shows a block diagram of an image retrieving apparatus in accordance with the second embodiment. The image retrieving apparatus 10 comprises an image input unit 1, a color converter 2, a retrieving area setting unit 3, an HQ histogram forming unit 4, an HQ histogram comparator 5, a similarity judging unit 6, an area position memory 7, and a similar area information output unit 8.

[0165] In comparison with FIGS. 1 and 21, it is found that the image retrieving apparatus 10 in the second embodiment is

very similar to that in the first embodiment, so that the explanation of the common elements are omitted.

[0166] The image retrieving apparatus 10 retrieves whether an input image 11 (see FIG. 22A) includes a retrieving image 13 (see FIG. 22B) similar to a retrieving image of an object to be retrieved or not by comparing the color histograms of the image in an area of the input image and the retrieving image.

[0167] In the image retrieving by the image retrieving apparatus 10 in accordance with the second embodiment, a retrieving area 12 having an optional size is selected in the input image 11 as shown in FIG. 22C. The retrieving area 12 is moved in predetermined directions at a predetermined pitch so as to scan whole the input image 11. A color histogram of an image in each retrieving area 12 is compared with a color histogram of the retrieving image 13. In the second embodiment, it is possible to retrieve several sizes of the retrieving image 13 by varying the size of the retrieving area 12.

[0168] When the number of pixels in the retrieving area 12 or the retrieving image 13 is equal to or smaller than a predetermined value due to the pixel density of the input image 11 is smaller or the size of the input image 11 is smaller, the image retrieving apparatus 10 generates smoothed color histograms in order to prevent the reduction of the image retrieving performance. In the second embodiment, a human face portion is used as the retrieving image to be retrieved as

shown in FIG. 22B.

[0169] The image input unit 1 takes an input image 11 and a retrieving image 13. For example, the input image 11 has 640 (horizontal direction)$\times$480 (vertical direction) pixels, and the retrieving image 13 has 15$\times$15 pixels. The input image 11 and the retrieving image 13 are respectively taken as an eight bit image data configured by R(red), G(green) and B(blue) color signals.

[0170] The color converter 2 converts the image data configured by R(red), G(green) and B(blue) color signals to another image data configured by hue (H) and compensated saturation (Q) by the above-mentioned equations (1) and (2) in the first embodiment.

[0171] The retrieving area setting unit 3 sets the size of the retrieving area 12 which is to be compared with the retrieving image 13. In the second embodiment, the retrieving area 12 has a rectangular shape, and an initial size "p" of the retrieving area 12 is selected to be 4/5 of the size of the input image 11. The retrieving area setting unit 3 further moves the retrieving area 12 by a predetermined pitch in each predetermined direction. The image retrieving is executed after each movement of the retrieving area 12.

[0172] When the image retrieving of the whole input image 11 by moving the retrieving area 12 is completed, the size "p" of the retrieving area 12 is reduced by a downsizing ratio "r", as

shown in FIG. 22D. The image retrieving will be repeated by the same manner until the size "p" of the retrieving area 12 becomes equal to or smaller than a predetermined size "P".

[0173] In the second embodiment, the initial size "p" of the retrieving area 12 is selected in view of the maximum size of the human face portion which can be included in the input image 11. By selecting the initial size "p" of the retrieving area 12 be 4/5 of the size of the input image 11, it is possible to prevent to missing the retrieving of the largest human face portion which can be existed in the input image 11. Since the number of the pixels of the input image 11 is 640×480 pixels, the initial value of the pixels of the retrieving area 12 becomes 512×384 pixels.

[0174] Since the downsizing ratio "r" is selected to be r=0.8 in the second embodiment, the size "p" of the retrieving area 12 will be downsized to be 410×307, 328×246, 262×197, ··· pixels. The number of the pixels are rounded to be the integer. By repeating the image retrieving with the reduction of the size of the retrieving area 12, it is possible to prevent the missing of the retrieving with no relation to the size of the retrieving image 13.

[0175] The predetermined size "P" is selected to be 1/10 of the size of the input image 11. Thus, the pixels of the predetermined size "P" becomes 64×48 pixels. This size is selected to be the minimum size in view of the case that a human face portion is existed as a part of an object in the input image

11.

[0176] The pitches of the movement of the retrieving area 12 in both direction are respectively set to be "1" as the minimum pitch of the movement. By such the selection, it is possible to execute the image retrieving with no missing. The position of the retrieving area 12 is designated by using any one of the coordinates at the four corners and the center of the rectangular.

[0177] The HQ histogram forming unit 4 shown in FIG. 21 generates the normalized color histograms with using the H and Q data of the input image with respect to each retrieving area set by the retrieving area setting unit 3. Furthermore, the HQ histogram forming unit 4 generates the normalized color histograms with using the H and Q data of retrieving image.

[0178] The HQ histogram forming unit 4 generates a color histogram with a predetermined resolution of gradation "N". As shown in FIGS. 4A and 4B showing the examples of the color histograms respectively having the resolution of gradation N=16 and N=256, it is found that the image retrieving can be made faster owing to the shortening of the calculation time by reducing the resolution of gradation "N". In the second embodiment, the resolution of gradation "N" is selected to be 256 (N=256) corresponding to the highest resolution of image retrieving apparatus 10.

[0179] The HQ histogram forming unit 4 further judges whether the number of pixels of the retrieving area 12 and the

retrieving image 13 is smaller than a predetermined value "D" or not. When the number of pixels is smaller than the predetermined value "D", the HQ histogram forming unit 4 generates a smoothed color histogram in which the degrees of the histogram are smoothed. In the second embodiment, the predetermined value "D" is selected to be 256 corresponding to the highest resolution of image retrieving apparatus 10.

[0180] The smoothening process of the degree is described with reference to FIGS. 23A to 23D. In the smoothing process, the interpolation is executed at two steps. At first, the interpolation of the degree is executed with respect to a gradation having a positive value of the degree but extremely smaller than the degrees of the neighboring gradations. Subsequently, the interpolation of the degree is executed with respect to a gradation having the value zero of the degree.

[0181] As shown in FIGS. 23A and 23B, with respect to a predetermined gradation "ni" having a positive value "Pi" of degree, other gradations "nk" and "nj" respectively having positive values "Pk" and "Pj" of degrees are considered in the higher gradation side and the lower gradation side. The smaller one of the values "Pk" and "Pj" is selected to be the minimum degree P_{min}. When a ratio of the value "Pi" of the gradation "ni" with respect to the minimum degree P_{min} is smaller than a predetermined ration, for example, $Pi \leqq P_{min}/3$, it is judged that the value "Pi" of degree of the gradation "ni" is extremely

smaller than the values "Pk" and "Pj" of the neighboring gradations "nk" and "nj". Thus, the value "Pi" of degree of the gradation "ni" is converted by the following equation (3).

$$Pi=Pj+(Pk-Pj)\cdot(ni-nj)/(nk-nj) \qquad \cdots(3)$$

[0182] By such the converting process, the value "Pi" of degree of the gradation "ni" will be changed to be a value shown by dotted line in FIG. 23B from the original value shown by solid line in FIG. 23A. The value "Pi" after the conversion corresponds to a linearly interpolated value of the values "Pk" and "Pj".

[0183] Subsequently, as shown in FIGS. 23C and 23D, with respect to a predetermined gradation "nd" having a value zero of degree, other gradations "ni" and "nj" respectively having positive values "Pi" and "Pj" of degrees are considered in the higher gradation side and the lower gradation side. The value "Pd" of degree of the gradation "nd" is converted by the following equation (4).

$$Pd=Pj+(Pi-Pj)\cdot(nd-nj)/(ni-nj) \qquad \cdots(4)$$

[0184] By such the converting process, the value "Pd" of degree of the gradation "nd" will be changed to be a value shown by dotted line in FIG. 23D from the original value zero shown in FIG. 23A. The value "Pd" after the conversion corresponds to a linearly interpolated value of the values "Pi" and "Pj".

[0185] The HQ histogram forming unit 4 further executes the normalization of the color histograms. The normalized color

histogram is the color histogram normalized that the sum of the degrees is to be "1" by dividing the number of pixels with respect to each gradation by the total number of the pixels in the retrieving area.

[0186] The HQ histogram comparator 5 show in FIG. 21 compares the color histogram of the retrieving area 12 of the input image 11 with the color histogram of the retrieving image 13. The similarity judging unit 6 calculates the similarity "Sm" between the compared color histograms and judges whether the similarity "Sm" is higher than a predetermined level "S" or not. A retrieving area 12 having the similarity "Sm" larger than the predetermined level "S" is judged as the area in which the retrieving image 13 is included. The predetermined level "S" can be selected to be a suitable value corresponding to the desired image retrieving accuracy. In the second embodiment, the predetermined level "S" is selected to be 0.8 (S=0.8). The value of the similarity "S" can be obtained by the same manner shown in FIGS. 5A to 5C in the first embodiment.

[0187] The area position memory 7 in FIG. 21 memorizes positions of the retrieving areas 12 which have the similarities "Sm" larger than the predetermined level "S" as an area 14 in which the retrieving image 13 is included (see FIG. 22E). The similar area information output unit 8 outputs the area 14 including the retrieving image 13 memorized in the area position memory 7 as a result of the image retrieving.

[0188] Subsequently, steps of the image retrieving in the image retrieving apparatus in accordance with the second embodiment is described with reference to FIG. 24. FIG. 24 is a flowchart showing a main routine of the image retrieving steps.

[0189] In the step #500, the input image 11 and the retrieving image 13 to be retrieved are taken as the image data based on the R, G and B signals (see FIGS. 22A and 22B). Subsequently, the image data based on the R, G and B signals are converted to other image data based on the H and Q data (#505). The H and Q data of the retrieving image 13 is taken (#510), and the normalized color histogram of the retrieving image 13 is formed (#515). Details of the forming of the normalized color histogram will be described below with reference to FIG. 25 showing a subroutine flow.

[0190] Subsequently, the H and Q data of the retrieving area 12 in the input image 11 (see FIG. 22C) is taken (#520), and the normalized color histogram of the retrieving area 12 is formed (#525).

[0191] A similarity "Sm" between the normalized color histograms is calculated (#530), and the similarity "Sm" is compared with the predetermined level "S" (#535). When the similarity "Sm" is larger than the predetermined level "S" (Sm>S: YES in the step #535), the position information with respect to the retrieving area 12 is memorized in the area position memory 7 (#540).

[0192] When the similarity "Sm" is equal to or smaller than the predetermined level "S" ($Sm \leqq S$: NO in the step #535) or when the position information is memorized in the step #540, it is judged whether the movement of the retrieving area 12 is scanned whole the input image 11 or not (#545). When the whole of the input image 11 has not been scanned (NO in the step #545), the retrieving area 12 is moved by the predetermined pitch in the vertical or horizontal direction (#550) and returns to the step #520.

[0193] When the whole of the input image 11 has been scanned (YES in the step #545), the size "p" of the retrieving area 12 is compared with the predetermined size "P" (#555). When the size "p" of the retrieving area 12 is larger than the predetermined size "P" ($p>P$:NO in the step #555), the size "p" of the retrieving area 12 is downsized by the downsizing ratio "r" as shown in FIG. 22D (#560), and returns to the step #520. Alternatively, when the size "p" of the retrieving area 12 is equal to or smaller than the predetermined size "P" ($p \leqq P$:YES in the step #555), the position information of the retrieving area 12 memorized in the area position memory 7 is outputted as the position information of the area 14 in which the retrieving image 13 is included as shown in FIG. 22E (#565), and this subroutine flow is completed.

[0194] In FIG. 25 showing the subroutine for forming the normalized color histogram in the steps #515 and #525, the color

histogram is formed with the predetermined resolution of gradation "N" (N=256 in the second embodiment) from the H and Q data of the retrieving image 13 or the retrieving area 12 of the input image 11 (#600). Subsequently, the total number "Dt" of pixels of the image data is judged whether it is smaller than a predetermined value "D" or not (#605).

[0195] When the total number "Dt" is smaller than the predetermined value "D" (YES in the step #605), the degrees of the gradations in the color histogram formed in the step #600 are judged whether the degree with respect to each gradation is a positive value but equal to or smaller than a predetermined value or not (#610). In the second embodiment, the predetermined value is $P_{min}/3$ when a smaller value of degrees of the neighboring gradations in the high gradation side and the low gradation side is selected as the minimum value P_{min}.

[0196] When the degree with respect to the gradation is the positive value but equal to or smaller than the predetermined value (YES in the step #610), the interpolation of the data is executed by following the above-mentioned equation (3) (#615). When the degree with respect to the gradation is not the positive value and larger than the predetermined value (NO in the step #610) or when the interpolation of the data is completed in the step #615, it is judged whether the judgment of the degrees with respect to all the gradations has been completed or not (#620). When the judgment has not been completed, it will return to the

step #610, and the above-mentioned steps be repeated.

[0197] When the judgment of the degrees with respect to all the gradation has been completed (YES in the step #620), the degree with respect to each gradation of the color histogram is judged whether the value of the degree is zero or not (#625). When the value of the degree is zero (YES in the step #625), the interpolation of the data is executed by following the above-mentioned equation (4) (#630). When the value of the degree is not zero (NO in the step #625) or when the data is interpolated in the step #630, it is judged whether the judgment of the degrees with respect to all the gradations has been completed or not (#635). When the judgment has not been completed, it will return to the step #625, and the above-mentioned steps be repeated.

[0198] When the total number "Dt" is equal to or larger than the predetermined value "D" (NO in the step #605) or when the judgment of the degrees with respect to all the gradation has been completed (YES in the step #635), the color histogram is normalized (#640), and this subroutine flow will be completed.

[0199] In the second embodiment, the input image 11 has 640×480 pixels, and the retrieving image 13 has $15 \times 15 = 225$ pixels, so that the total number 225 of pixels of the retrieving image 13 is smaller than the predetermined value D=256. Thus, the smoothed color histogram of the retrieving image 13 can be formed.

[0200] As mentioned above, the total number of pixels of the image data is judged whether it is equal to or smaller than the predetermined value "D" or not and the smoothing process is executed to the color histogram of the image data when the total number of pixels is equal to or smaller than the predetermined value "D". Thus, it is possible to prevent the color histogram of the image data be the comb shape. Furthermore, it is possible to prevent the large reduction of the similarity between the histograms due to a minute discrepancy of the gradation when the histograms have comb shapes. Still furthermore, it is possible to prevent the reduction of the image retrieving performance when the number of pixels of the input data becomes much larger.

[0201] In the smoothing process, the interpolation of the vale of the degree is executed with respect to the value of the degree when it is a positive value but extremely smaller than other values of the degrees of the neighboring gradations. Subsequently, the interpolation of the value of the degree is executed with respect to the gradation having the value of the degree is zero. Thus, the histogram having a smoothed shape can surely be formed, so that it is possible to prevent that the histogram has a comb shape.

[0202] A modification of the image retrieving apparatus in accordance with the second embodiment will be described. The electrical block diagram of the modified image retrieving apparatus is substantially the same as that shown in FIG. 21.

The smoothing process by the HQ histogram forming unit 4 is different.

[0203] In this modification, the HQ histogram forming unit 4 executes the smoothing process by roughing the resolution of gradation "N" when the number of pixels of the retrieving area 12 of the input image 11 or the retrieving image 13 is equal to or smaller than the predetermined value "D".

[0204] The HQ histogram forming unit 4 compares a number of pixels "Dn" of the retrieving area 12 with a number of pixels "Dk" of the retrieving image 13. The HQ histogram forming unit 4 further compares the smaller value "K" of the numbers "Dn" and "Dk" with the predetermined value "D". When K<D, it selects the resolution of gradation N=K/5 which will be used for forming a color histogram.

[0205] Steps of the image retrieving in the modified image retrieving apparatus in accordance with the second embodiment is described with reference to FIG. 26. FIG. 26 is a flowchart showing a main routine of the image retrieving steps.

[0206] In the step #700, the input image 11 and the retrieving image 13 to be retrieved are taken as the image data based on the R, G and B signals (see FIGS. 22A and 22B). Subsequently, the image data based on the R, G and B signals are converted to other image data based on the H and Q data (#705).

[0207] The H and Q data of the retrieving image 13 is taken, and the number of pixels "Dk" is counted (#710). The number

of pixels "Dk" in this modification is 15×15=255. Similarly, the H and Q data of the retrieving area 12 is taken, and the number of pixels "Dn" is counted (#715). Since the initial value of the size of the retrieving area 12 is 4/5 of the size of the input image 11, the initial value of the number of pixels "Dn" of the retrieving area 12 becomes 512×384=196608.

[0208] Subsequently, the resolution of gradation "N" which will be used for forming the color histograms of the retrieving area 12 and the retrieving image 13 is selected (#720). Details of the selection of the resolution of gradation "N" will be described below with reference to FIG. 27 showing a subroutine flow. The normalized color histogram of the retrieving image 13 is formed with using the resolution of gradation "N" (#725).

[0209] Subsequently, the image data of the retrieving area 12 in the input image 11 (see FIG. 22C) is taken (#730), and the normalized color histogram of the retrieving area 12 is formed (#735).

[0210] A similarity "Sm" between the normalized color histograms is calculated (#740), and the similarity "Sm" is compared with the predetermined level "S" (#745). When the similarity "Sm" is larger than the predetermined level "S" (Sm>S: YES in the step #745), the position information with respect to the retrieving area 12 is memorized in the area position memory 7 (#750).

[0211] When the similarity "Sm" is equal to or smaller than

the predetermined level "S" (Sm≦S: NO in the step #745) or when the position information is memorized in the step #750, it is judged whether the movement of the retrieving area 12 is scanned whole the input image 11 or not (#755). When the whole of the input image 11 has not been scanned (NO in the step #755), the retrieving area 12 is moved by the predetermined pitch in the vertical or horizontal direction (#760) and returns to the step #730.

[0212] When the whole of the input image 11 has been scanned (YES in the step #755), the size "p" of the retrieving area 12 is compared with the predetermined size "P" (#765). When the size "p" of the retrieving area 12 is larger than the predetermined size "P" (p>P :NO in the step #765), the size "p" of the retrieving area 12 is downsized by the downsizing ratio "r" as shown in FIG. 22D (#770), and returns to the step #715 so as to be counted the number of pixels "Dn" with respect to the downsized size of the retrieving area 12. Alternatively, when the size "p" of the retrieving area 12 is equal to or smaller than the predetermined size "P" (p≦P :YES in the step #765), the position information of the retrieving area 12 memorized in the area position memory 7 is outputted as the position information of the area 14 in which the retrieving image 13 is included as shown in FIG. 22E (#775), and this subroutine flow is completed.

[0213] In FIG. 27 showing the subroutine for selecting the resolution of gradation "N" in the steps #720, the number of

pixels "Dk" of the retrieving image 13 is compared with the number of gradation "Dn" of the retrieving area 12 (#800), and the smaller value of "Dk" and "Dn" is selected as the number of pixels "K" (#805 and #810).

[0214] Subsequently, the number of pixels "K" is compared with the predetermined value "D" (#815). When the number of pixels "K" is smaller than the predetermined value "D" ($K<D$) (YES in the step #815), the value of the resolution of gradation "N" is selected to be K/5 ($N=K/5$) (#820). When the number of pixels "K" is equal to or larger than the predetermined value "D" ($K \geqq D$) (NO in the step #815), the value of the resolution of gradation "N" is selected to be the maximum value of the resolution of gradation, for example 256 (#825).

[0215] In this modification, when the number of pixels $Dk=15\times 15=255$ and the size "p" of the retrieving area 12 takes the initial value, the number of pixels $Dn=512\times 384=196608$. Since the value "Dk" is smaller than the value "Dn" ($Dk<Dn$), the number of pixels "K" is selected to take the value "Dk" ($K=Dk$). Hereupon, there is a relation that $K=225<D=256$, so that the number of the resolution of gradation "N" becomes 45 ($N=225/5=45$). The color histograms are formed with the resolution of gradation $N=45$.

[0216] In this modification, when the smaller number of pixels "k" of the number of pixels "Dn" of the retrieving area 12 and the number of pixels "Dk" of the retrieving image 13 is equal

to or smaller than the predetermined value "D", the resolution of gradation "N" is elected to be smaller such as N=K/5 used for forming the color histograms in the smoothing process of the degrees. Thus, it is possible to prevent that the shape of the histogram becomes comb shape, and to prevent the reduction of the image retrieving performance.

[0217] Furthermore, the color histograms are formed by roughing the resolution of gradation in the smoothing process of the degrees, so that the burden in the calculation can be reduced and the time for retrieving the image can be shortened.

[0218] Hereupon, a width "n" of a gradation of the color histogram can be obtained by the following equation.

n=(maximum resolution of gradation)/N

[0219] Furthermore, when it is supposed to occur the luminance variation or color fogging on the image of the object, it is preferable to increase the width "n" of the gradation for reducing the affect of the variation of the luminance or the color fogging. For example, the width "n" of the gradation should be n=n+0.3 with respect to the hue (H) data, and the width "n" of the gradation should be n=n+30 with respect to the compensates saturation (Q) data. The increased width +0.3 or +30 can be decided by basing on the variation of the hue (H) or the compensated saturation (Q) caused by the color fogging or the under exposure on the image taken by, for example, the digital still camera.

[0220] Another modification of the smoothing process of the degrees in the forming of the color histogram by the HQ histogram forming unit 4 is described below with reference to FIGS. 28A to 28E.

[0221] FIG. 28A shows a basic color histogram having a comb shape due to the number of pixels is smaller. The numbers of the degrees with respect to the gradations "n2" and "n5" are extremely smaller than the numbers of degrees of the neighboring gradations. The values of the degrees with respect to the gradations "n3" and "n7" are zero.

[0222] FIG. 28B shows an example of an interpolated color histogram. The positive values of the degrees in the same histogram as shown in FIG. 28A are serially bounded by dotted lines. This example, however, is not preferable because the color histogram becomes a comb shape in the vicinity of the gradations "n2" and "n5" respectively having the extremely smaller values of the degrees.

[0223] FIG. 28C shows another example of an interpolated color histogram. The positive values of the degrees except the extremely smaller values corresponding to the gradations "n2" and "n5" in the same histogram as shown in FIG. 28A are serially bounded by solid lines. The value of the degree with respect to the gradation "n2" is interpolated to be a value on the solid line bounding the values of degrees with respect to the gradations "n1" and "n4" by following the above-mentioned equations (3)

and (4). Similarly, the value of the degree with respect to the gradation "n5" is interpolated to be a value on the solid line bounding the values of degrees with respect to the gradations "n4" and "n6". In this example, the upper and lower limits of the gradation are linearly interpolated so that the predetermined minimum gradation such as zero and the predetermined maximum gradation such as "255" becomes zero. Alternatively, it is possible to select the upper and lower limits of the gradation in a manner so that the gradation decided by basing on a difference between two gradations respectively taking positive values of the degrees on the higher limit side and the lower limit side should be zero.

[0224] FIG. 28D shows still another example of an interpolated color histogram. The values of the degree with respect to the gradations "n2" and "n5" are interpolated by substantially the same manner in the example shown in FIG. 28C. The values of degree with respect to the gradations "n3" and "n7" are interpolated to take the same value as the smaller one of the values with respect to adjoining gradations. By such the interpolation, the color histogram can be formed with a relatively rough resolution of gradation corresponding to the number of the gradations having the positive values of degree.

[0225] FIG. 28E shows still another example of an interpolated color histogram. The values of the degree with respect to the gradations "n2" and "n5" which are extremely

smaller and the values of degree with respect to the gradations "n3" and "n7" taking the value zero are interpolated to take the same value as the smaller one of the values with respect to adjoining gradations. In this case the values of the degree with respect to the gradations "n2" and "n5" are regarded as zero. By such the interpolation, the color histogram can be formed with a rough resolution of gradation corresponding to the number of the gradations having the positive values of degree except the gradations having extremely smaller values and zero.

[0226] By using the smoothing process shown in FIGS. 28C or 28D, it is possible to prevent that the histogram have a comb shape even when the number of pixels of the image data is smaller. Furthermore, when the smoothing process shown in FIG. 28E is used, the accuracy of the image retrieving is reduced than that in the case using the smoothing process shown in FIG. 28D, but it is possible to prevent that the color histogram has a comb shape. Especially, when the smoothing process shown in FIG. 28D or 28E is used, the burden of the calculation can be reduced largely than the case using other smoothing process, so that the time of the image retrieving can be shortened.

[0227] When the gradation having the extremely smaller value of degree such as the gradation "n2" or "n52 in FIG. 28A is not existed in the histogram, it is possible to interpolate the values of degree by using the values on the lined bounding the positive peak values of degree. By such the interpolation, the

histogram may not have a comb shape.

[0228] In the above-mentioned second embodiment, the hue (H) and the compensated saturation (Q) are used as the color space. It, however, is possible to use the R, G and B signals. Furthermore, it is possible to use another color system such as the HIS (Hue, Intensity, Saturation) color system, the L*a*b* color system, or the L*u*v* color system.

[0229] It is possible further to provide an operating unit 91 illustrated by dotted line in FIG. 21 showing the configuration of the image retrieving apparatus in accordance with the second embodiment. By such a modification, it is possible to input the values of the parameters such as the value of the resolution of gradation "N", the size "p" of the retrieving area 12, the values of the pitches of the retrieving area 12, the values of the predetermined level "S", and so on by using the operating unit 91.

[0230] In the above-mentioned second embodiment, the retrieving image 13 is taken by the image input unit 1. It, however, is possible further to provide an retrieving data memory 92 illustrated by dotted line in FIG. 21. The data with respect to the retrieving image 13 is previously memorized in the retrieving data memory 92. In this modification, it is possible to memorize the R, G and B signals as the data of the retrieving image 13. Alternatively, it is possible to memorize the H and Q data converted from the R, G and B signals as the data of the retrieving image 13.

[0231] Furthermore, it is possible to memorize the normalized color histogram based on the H and Q data as the data of the retrieving image 13 in the retrieving data memory 92. In this case, it is further possible to memorize the normalized color histograms which are formed with the resolution of gradation "N".

[0232] A digital still camera using the image retrieving apparatus in accordance with the second embodiment is described. The digital still camera 100 has substantially the same configuration as shown in FIG. 16. The image retrieving apparatus 10 in the digital still camera 100 corresponds to that shown in FIG. 21.

[0233] Table 2 shows the degree for the edge emphasizing operation and the gradation characteristic (γ) with respect to each region of the size of the human face portion. Filters used in the edge emphasizing operation are the same as them shown in FIGS. 18A to 18C.

table 2

RATIO OF HUMAN FACE PORTION	DEGREE OF EDGE EMPHASIZING	GRADATION CHARACTERISTIC
LARGE (30 to 100%)	WEAK	γ =1.1 (a in FIG. 29)
MIDDLE (10 to 30%)	MIDDLE	γ =1.15 (b in FIG. 29)
SMALL (5 to 10%)	MIDDLE	γ =1.2 (c in FIG. 29)
NOT RETRIEVED	STRONG	γ =1.25 (d in FIG. 29)

[0234] As can be seen from table 2, when the ratio of the

size of the retrieving area including the human face portion with respect to the size of the input image is in the range from 30 to 100 %, the filter shown in FIG. 18C having the low degree for edge emphasizing effect is used for emphasizing the edge of the retrieving area including the human face portion. When the ratio of the size of the retrieving area including the human face portion with respect to the size of the input image is in the range from 5 to 30 %, the filter shown in FIG. 18B having the middle degree for edge emphasizing effect is used for emphasizing the edge of the retrieving area. On the other hand, when the human face portion is not retrieved in the input image, the filter shown in FIG. 18A having the high degree for edge emphasizing effect is used for emphasizing the edge of the retrieving area.

[0235] FIG. 29 shows examples of the gradation characteristics (γ characteristic curves) used in the gradation compensation process by the image processing unit 105. The gradation compensation process is executed corresponding to the size of the retrieving area after a compensation for reversing the input/output characteristics of a monitor.

[0236] As can be seen from table 2, when the ratio of the size of the retrieving area including the human face portion with respect to the size of the input image is in the range from 30 to 100 %, the γ characteristic curve "a" (γ =1.1) shown in FIG. 29 is used for compensating the gradation. When the ratio of the size of the retrieving area including the human face portion with

respect to the size of the input image is in the range from 10 to 30 %, the γ characteristic curve "b" (γ =1.15) shown in FIG. 29 is used for compensating the gradation. When the ratio of the size of the retrieving area including the human face portion with respect to the size of the input image is in the range from 5 to 10 %, the γ characteristic curve "c" (γ =1.2) shown in FIG. 29 is used for compensating the gradation. On the other hand, when the human face portion is not retrieved in the input image, the γ characteristic curve "d" (γ =1.25) shown in FIG. 29 is used for compensating the gradation.

[0237] A boundary, for example, 30% of the regions of the ratio of the size of the retrieving area with respect to the size of the input image are to be included in one of the adjoining two regions. The boundaries are not restricted by the examples shown in table 2. It is possible to select proper values corresponding to the characteristic of the digital still camera 100.

[0238] The above-mentioned modification is described with respect to the digital still camera. The image retrieving apparatus 10 in accordance with the second embodiment can be applied to another imaging apparatus such as a digital video camera for recording a movie.

[0239] Still furthermore, it is possible to apply the image retrieving apparatus 10 to a printer. A block diagram for showing an example of an electric configuration of the printer using the image retrieving apparatus 10 in accordance with the

second embodiment is substantially the same as that in the first embodiment shown in FIG. 20. The explanation of the printer is omitted.

[0240] Although the present invention has been fully described by way of example with reference to the accompanying drawings, it is to be understood that various changes and modifications will be apparent to those skilled in the art. Therefore, unless otherwise such changes and modifications depart from the scope of the present invention, they should be construed as being included therein.